POWERFUL SOLUTIONS - HITACHI EXCITATION SYSTEM

VCS-6000
The expansion of the power distribution network in recent years increased the necessity for stable operation of individual generators. Known issues in this context are a decrease in stability as transmission distances and load inconsistencies increase. For green site unit projects and modernization projects, high system efficiency and easy maintenance of control devices are mandatory in the electric power industry. For modernization projects, system and spare part obsolescence are also important decision factors in deploying a new excitation system.

The Digital Automatic Voltage Regulator and Power System Stabilizer are the most cost effective measures in power transmission stabilization strategies. HITACHI’s solution is the digital, static VCS-6000 Excitation System with the integrated Power System Stabilizer. Using a state-of-the-art 32 bit RISC processor, the VCS-6000 integrates various functions into the voltage control system to achieve a responsive and reliable network.
Key Components of Digital-AVR Control

The primary function of the Digital AVR is regulating the generator voltage and matching it with the voltage reference value (90% set point). Hence, the AVR has a key role in supplying stable voltage during power swings in the power generation network.

Required Functions:
- Multifunction Controller
- High Reliability (system redundancy, self-diagnostic function, compact design)
- Centralized System Supervision
- Ease of Operation, Maintenance, and Safety
- Power System Stabilizer

Outline of Digital-AVR

<table>
<thead>
<tr>
<th>Power Stability</th>
<th>Proposed improvement by means of generator Excitation System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transient</td>
<td>AVR: Maintenance of Generator Voltage</td>
</tr>
<tr>
<td>Dynamic</td>
<td>PSS: Improvement of the power system stability</td>
</tr>
</tbody>
</table>

AVR: Automatic Voltage Regulator
PSS: Power System Stabilizer

Diagram showing the interaction between the main elements of the power system, including the generator, transformer, and power grids, highlighting the role of the AVR in maintaining voltage stability and its proposed improvements through system stabilization.

Key Terms:
- AVR: Automatic Voltage Regulator
- PSS: Power System Stabilizer
**CONTROL SYSTEM CONFIGURATION**

**Parallel Redundant Control System**
Each control channel A/B has parallel control hardware for gate signal control and for I/O signal interface. Hence, there is no impact on plant operation if one channel failure occurs.

**Capacity Expansion**
Each control channel A/B has the capability to fire 10 parallel thyristor bridges. Hence, there is no limitation to the excitation rating.

**Diagnostic Identification**
The HMI stores fault information with time stamp for both control channels.

**Typical Thyristor Excitation System VCS-6000 (Redundant AVR)**

- **VCMi (A), VCMi (B):** Voltage Control Module Integrated
- **GPG:** Gate Pulse Generator
- **EX-TR:** Excitation Transformer
- **GDIO:** Gate Driver & I/O
- **CBC:** Crow-Bar Circuit
- **HMI:** Human Machine Interface
- **RDIO:** Remote Digital I/O
- **PS:** Power Source

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**Typical dimensions for 375VDC / 2000ADC class**

- **AC-FCB:**
  - 39.4" (1,000)
  - 43.3" (1,100)
  - 165.4" (4,200)

- **THY (1):**
  - 39.4" (1,000)

- **THY (2):**
  - 43.3" (1,100)

- **AVR:**
  - 90.6" (2,300)
  - 47.2" (1,200)

**inches (mm)**
Example of AC Field Circuit Breaker Control System Arrangement

- **LOCAL OPERATION / MONITORING**
  - **MAIN MENU**
  - **ONLINE PROCESS MONITOR**
  - **CONTROL PANEL**

- **FAN POWER SUPPLY CONTACTOR**
- **COOLING FAN**
  - Each THY panel has online maintenance capability of the fan (hot-swap)
- **THYRISTOR BRIDGE SECTION**
  - Hitachi design is based on N+1 parallel redundancy as a standard.
- **AC FIELD CIRCUIT BREAKER (41)**
  - Main field circuit breaker provides disconnect from excitation field circuit.
  - AC-FCB is applicable for the ratings: 690V AC, 4,000 ADC.
- **GDIO**
  - Supplies the gate pulse to the thyristor from the gate trigger signal received from VCM.
  - Functions:
    - Gate pulse adjustment
    - Digital input: 16 points
    - Digital output: 6 points
- **VCM**
  - *Signal detection (V, P, Q, f, Vfdc etc.)
  - *AVR control
  - *Analog input: 20 points
  - *Analog output: 7 points
  - *Gate pulse generator
  - *Historical trend data record
- **FAN POWER SUPPLY CONTACTOR**
- **HPSI**
  - High potential signal interface for signal calculation at VCM.
  - Input Signals:
    - EX-TR secondary voltage
    - Generator field voltage
    - Generator field current
    - Crow-bar voltage
- **RDIO**
  - VCM controls these I/O signals through the optical cable transmission between RDIO and VCM.
  - *Digital input: 16 points
  - *Digital output: 10 points
- **HMI**
  - (mounted on the front panel of AVR)

**VCS-6000 FEATURES**

**ADAPTABILITY**

The VCS-6000 Automatic Voltage Regulator has been installed in all sizes of applications from small rotating excitation system to large static excitation system.

**FLEXIBILITY**

Selection of simplex or redundant system is available as required by the customer.

**RELIABILITY**

VCS-6000 assures high component reliability as a result of the following approach:

- Consolidated design results in fewer boards and less internal wiring.
- Varnish coating for all boards inhibits corrosion and extends life.
- Aging test for all boards.

**STABILITY & REDUNDANCY**

Complete parallel redundant Excitation System through the following design features:

- Assuring stable plant operation by application of two parallel control channels.
- Assuring stable plant operation by implementation of N+1 Thyristor bridge circuits as standard design.
- Assuring stable plant operation by application of DC/DC & AC/DC control power supplies.

**ELECTRO-MAGNETIC INTERFERENCE**

Application of optical cable minimizes electro-magnetic influence of signals. Application of fiber-optic cables for gate-firing signals eliminates susceptibility to electromagnetic interference.

**EASE OF USE**

VCS-6000 provides diagnostic functions, control functions and limiters as follows:

- Fault detection of each module by sophisticated self-diagnostic function.
- High-speed historical trend; records data for testing and fault analysis.
- Soft start function for prevention of generator voltage over-shooting.
- Auto tracking function between actual operating mode and other control modes for bumpless transfer.
- Enhanced crow-bar circuit prevents energy from coming back into the control system following a collapse of the field (CEMF)
- Local control panel support for quick troubleshooting using alarm history log (historian).

**LOCAL OPERATION**

One simple local operation screen on front door of AVR panel prevents confusion and potential for misoperation.

- Displays system parameters (Vg, Pg, Qg, etc.;)
- Raise/Lower commands of reference value.
- ON/OFF command and control mode selection command for excitation control for both channels in redundant system.

**MAINTAINABILITY**

VCS-6000 provides excellent maintainability of the excitation control system using the Commissioning & Maintenance Tool.

- Facilitates online replacement by isolation of disfunctional control channel from operation.
- One thyristor bridge per panel assembly improves maintainability and easy identification of disfunctional bridge.
- Safe maintenance, online monitoring and tuning with Commissioning & Maintenance Tool.
Potential Source Rectifier Exciter (THY-EX)

- Available maximum 10 thyristor (THY) cubicles depending on required exciter rating.
- AVR cubicle is same dimension for both single or duplicate AVR.

![Diagram](Fig 1) Apply AC-FCB
(Applicable for medium capacity generator)

![Diagram](Fig 2) 375VDC 2,000 A DC class cubicle dimension (Sample)

![Diagram](Fig 3) Apply DC-FCB
(Applicable for large capacity generator)

![Diagram](Fig 4) 500VDC 8,000A DC class cubicle dimension (Sample)

Brushless Exciter (BL-EX)

![Diagram](Fig 5) Brushless Exciter with PMG
(Mainly apply for fossil power plant)

![Diagram](Fig 6) Brushless Exciter without PMG
(Mainly apply for hydro power plant)

Alternator-Rectifier Exciter (AC-EX)

![Diagram](Fig 7) AVR cubicle dimension (Sample)

![Diagram](Fig 8) AC-EX with HFG

![Diagram](Fig 9) 200 VDC 200 A class Cubicle Dimension (Sample)
This product is protected by the following patents and/or patent pendings.